Natural Reforestation On A Mile-Square Clearcut In Southeast Alaska

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INTRODUCTION

Prompt and adequate restocking of cutover land is a primary concern of forest managers. After clearcutting, the forest cover must be reestablished promptly to restore the landscape's natural beauty, to minimize erosion, and to assure a sustained yield of timber from productive forest land. Natural regeneration requires little or no investment and so is preferable if the resulting stands compare favorably with those originating under artificial methods.

Large-scale timber harvesting in Alaska began in 1953, providing timber for the State's first modern pulpmill. A second mill entered production in 1959, and more are expected to follow. A study of natural regeneration began in 1954 on the Maybeso Experimental Forest near Hollis, Prince of Wales Island, Alaska. One cutting unit, referred to here as the "mile-square" unit (fig. 1), was made especially large to determine distance of seed dispersal. This 700-acre cutting unit is approximately square and has a southwest exposure. It varies in steepness from a flat flood plain adjacent to Maybeso Creek to upper slopes in excess of 100 percent (45°). Elevation of the cutting unit ranges from 100 to 1,700 feet above sea level. Soils[1/] on the steep upper slopes are of the Karta series, consisting of moderately well-drained, very gravelly, loam soils derived from glacial till, and Tolstoi series of well-drained, very stony, silt loam soils overlying bedrock. On moderate slopes near the toe of steep slopes are moderately well-drained Karta soils derived from glacial till and well-drained soils (presently unclassified) from alluvial fan deposits. Imperfectly drained Wadleigh (very gravelly, silt loam soils) occur on glacial moraines and drumlins. Well-drained Tonowek loam and Tuxekan silt loam soils are common on the flat valley bottom. All but the Tonowek are podzols with thick, organic surface layers. Tonowek is a weakly developed alluvial soil.

The climate of Maybeso valley, as in all of southeast Alaska, is generally cool and moist

1/ Gass, C. R.; Billings, R. S.; Stevens, M. E.; and Stephens, F. R. Hollis area soil management report. (In preparation for publication, U.S. Forest Serv., Region 10.) Official soil series descriptions are available from U.S. Soil Conservation Service and U.S. Forest Service.

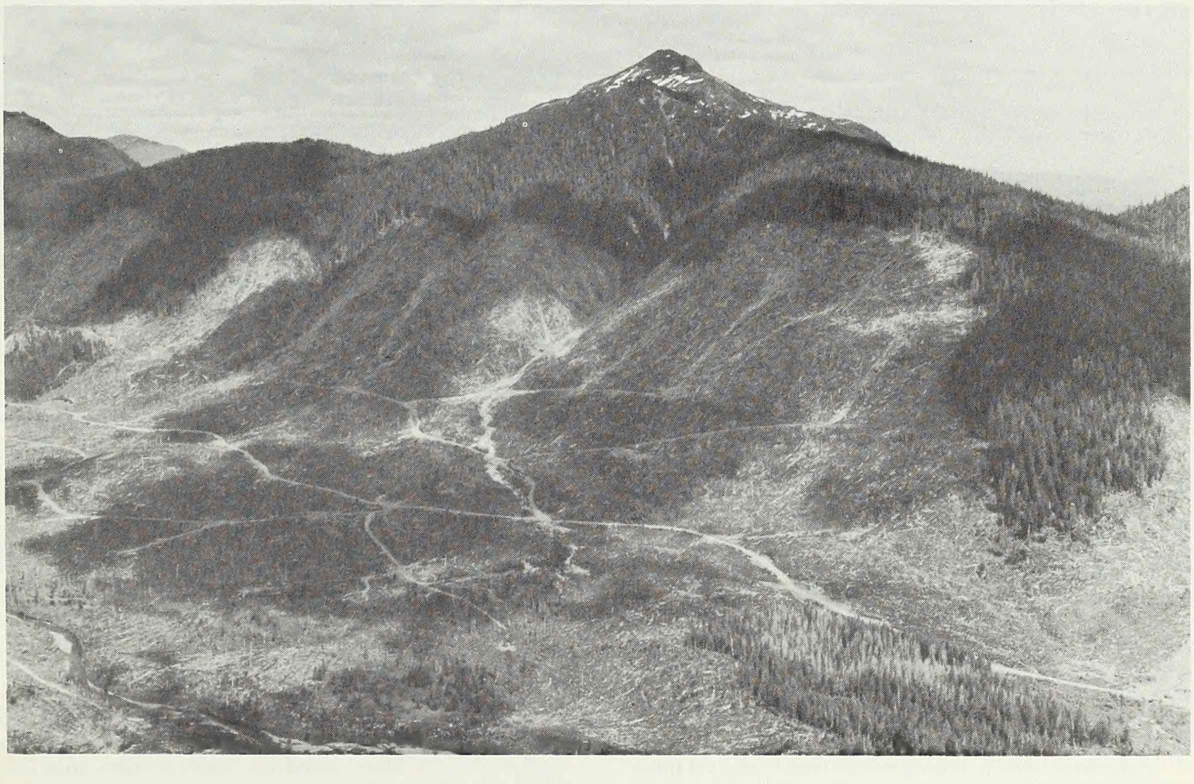

Figure 1.—The mile-square cutting unit lies between two timbered leave strips. Maybeso Experimental Forest, near Hollis, Alaska.

(Andersen 1955a).[2] The growing season extends from mid-May to mid-October. During the years 1954 to 1962, January temperatures were coldest with a 9-year average of 31.9° F. July was warmest with an average temperature of 58.3° F. Average monthly temperatures exceeded 60° F. during only 6 months: August 1954, 60.2° F.; August 1957, 62.2° F.; June 1958, 61.4° F.; July 1958, 62.2° F.; July 1961, 60.5° F.; and August 1961, 60.3° F.

Average annual precipitation during the years 1954 to 1962 was 104 inches. Precipitation was usually well distributed throughout each of the years with an average July low of 3.04 inches and an October high of 18.48 inches. During the 9-year period, at least 1.5 inches of precipitation fell each month with the exception of 4 months—0.42 inch during August 1954, 0.91 inch during July 1955, 0.56 inch during June 1958, and 0.80 inch during February 1962.

Within the growing season, the most noteworthy departure from the norm occurred during the abnormally hot and dry summer of 1958. From May 22 through July 18, only 0.61 inch of rain fell and daily maximum temperatures averaged 72° F. The highest temperature during the 9-year period occurred on June 3, 1958, when a maximum of 91° F. was recorded.

Logging on the mile-square cutting unit began in 1954 and was completed in 1957, with most done during 1954 and 1955. Logging was done by the high-lead system except for small areas that were tractor logged. The stand harvested was typical old growth composed of about 76 percent western hemlock,[3] 20 percent Sitka spruce, and 2 percent each of western redcedar and Alaska-cedar. Net timber volumes averaged 37,000 board feet (Scribner) per acre. Logging slash was left unburned.

This report describes restocking of the mile-square cutting unit in the first 9 years after logging began. It follows a progress report by James and Gregory (1959) describing regeneration on the cutting unit in 1958. Previous work by James and Gregory has been used freely throughout.

[2] Names and dates in parentheses refer to Literature Cited, p.16.

[3] Scientific names of plants mentioned are on page 15.

METHODS

For sampling tree regrowth, the cutting unit was divided into four zones, each 10 chains[4] wide, by distance from seed source (fig. 2). In 1957, after logging was completed,[5] 294 1-milacre circular plots were established and their centers marked with permanent stakes. Plot locations were selected randomly from a 2-chain grid superimposed on a cutting map. The number of plots sampled in each zone was allocated proportionately by area. These plots were reexamined during later surveys. A total of 308 plots were examined in 1958, 325 in 1960, and 321 in 1962. Differences in plot numbers examined during each survey were due to the loss of plots from roadbuilding or other ground disturbance and to additional plot establishment.

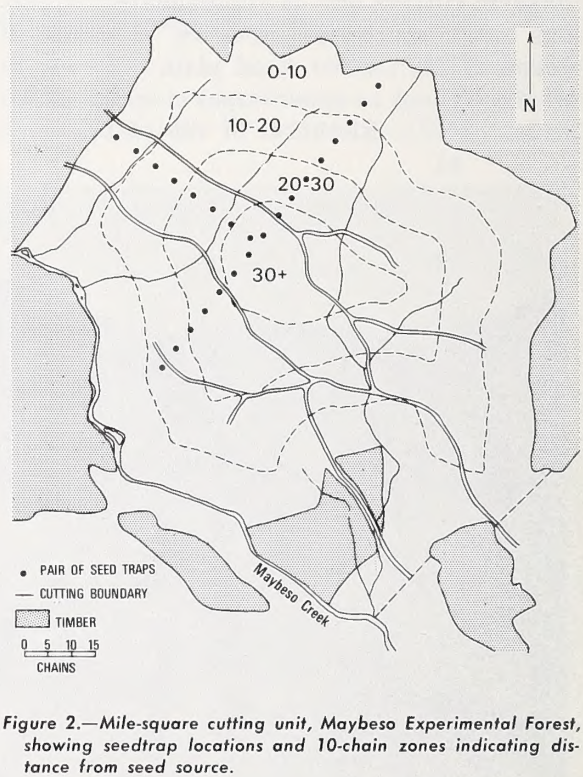

Figure 2.—Mile-square cutting unit, Maybeso Experimental Forest, showing seedtrap locations and 10-chain zones indicating distance from seed source.

[4] "Chain" as used in this paper is 66 feet.

[5] Approximately 350 acres were surveyed in 1955 when logging was still in progress. This survey included 162 4-milacre quadrats, each divided into four 1-milacre plots.

Seedlings were counted on 1-milacre circular plots and listed in three classes: Seedlings that germinated before the stand was harvested and that survived logging were called advanced; those that germinated after logging were called subsequent; within the latter group, seedlings less than 1 year old were listed separately. In 1962, cover type or ground conditions were described on each plot that contained no seedlings.

In addition to stocking percent measured on 1-milacre plots, stocking was also determined on 4-milacre circular plots located at each 1-milacre plot location. The height and species of the dominant seedling on each 4-milacre plot were recorded.

To provide information on seed dispersal, 48 seedtraps (2 feet by 3 feet) were installed on the cutting unit during August 1956 (fig. 3). Traps were placed in pairs, 33 feet apart, at 5-chain intervals for a distance of 1 mile from the upper timber edge in a southwesterly direction beginning 5 chains from timber (fig. 2). Another line of paired traps with the same spacing was placed in a southeasterly direction, beginning 5 chains from the west timber edge. Four seedtraps were placed in adjacent uncut timber. Traps were examined annually. To insure that seed came only from outside the cutting unit, residual trees of seed-bearing age left within the cutting unit were either felled or poisoned before seed ripened in 1956.

Figure 3.—Box-type seedtrap used to determine seed dispersal distance. Mile-square cutting unit, Maybeso Experimental Forest.

During the heavy seed crop of 1959-60, a daily record of seedfall was obtained from four seedtraps located in a timber stand about 1 mile east of the mile-square cutting unit. Weather records were obtained at a station midway between the cutting unit and the seed-trapping location. Traps were examined daily from October 1 through December 28, and finally in July 1960.

To determine the effect of seedbed and drainage on seedling establishment and early survival, forty-two 1-milacre plots representing seven seedbed conditions and two drainage classes, with three replications each, were selected or prepared in the spring of 1957. In May 1957, all plots were seeded with 100 seeds each of endrin-treated western hemlock and Sitka spruce to assure that some seed were present. The number of seed contributed to each plot from the natural seed source is not known. Seedling counts were made late in the summer of 1957 and annually thereafter until 1960. Seedlings were staked to show the year of germination.

Survival and growth of advanced seedlings were observed on eight ¼-milacre plots—four on well-drained alluvial soil and four on imperfectly drained Wadleigh soil. Plots included dense clumps of advanced seedlings, some of which were expected to survive. Survival and total height of seedlings were recorded in late summers from 1955 until 1961.

Table 1.—*Average annual seed catch since logging; mile-square cutting unit, Maybeso Experimental Forest*

SEED YEAR	AVERAGE SEEDS PER TRAP (6 square feet)	SPECIES COMPOSITION		
		Hemlock	Spruce	Cedar
	Number	- - -	*Percent*	- - -
1956-57[1/]	10.8	37	38	25
1957-58	13.8	95	3	2
1958-59	1.9	48	37	15
1959-60	40.8	39	46	15
1960-61	1.8	28	57	15
1961-62	.2	89	11	0

[1/] Incomplete data—include counts only until January 20, 1957.

RESULTS AND DISCUSSION

SEED PRODUCTION AND DISPERSAL DISTANCE

Seedtraps maintained in the cutover from 1956 to 1962 showed that some seed were dispersed from surrounding timber each year (table 1). However, only the 1957-58 and 1959-60 trap catches were large enough to provide meaningful estimates of seed dispersal distance.

The most striking relationship between trap catch and distance from seed source was provided by the 1959-60 seed crop (fig. 4). Seedfall decreased sharply up to 30 chains from seed source, less sharply thereafter. In comparison, the 1957-58 seed crop appeared to be more uniformly dispersed throughout the range of distance, although the relationship of trap catch to distance from seed source was highly significant.

An indirect measure of seed dispersal distance was provided by number of seedlings germinating from the two largest crops (table 2). Although overwinter storage and germination tend to obscure the relationship, the similar pattern of seedling establishment from the two crops is apparent. In both cases, number of seedlings germinating in each distance zone dropped sharply from the edge of timber to the 20- to 30-chain zone, increasing slightly in the

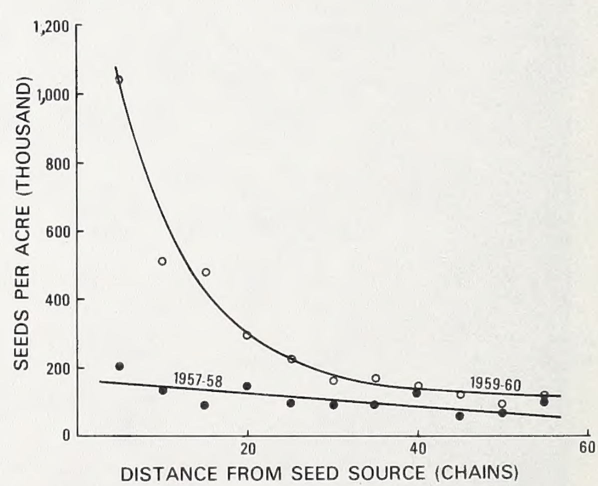

Figure 4.—Seed dispersal by distance from seed source, 1956-57 and 1959-60. Mile-square cutting unit, Maybeso Experimental Forest.

30+-chain zone. Percentage of plots in each zone stocked with at least two new seedlings followed a similar pattern by zone (table 2).

Seed production in uncut timber adjacent to the cutting unit was measured only during the 1957-58 seed year. Approximately 3.5 million seeds per acre were produced, 36 percent of which appeared sound by cutting test.

Table 2.—*A comparison of seedling germination following the two best seed years since logging; mile-square cutting unit, Maybeso Experimental Forest*

SEED YEAR	YEAR OF GERMINATION	CHAIN ZONE				ADJUST MEAN
		0-10	10-20	20-30	30+	
		Stems per acre				
1957-58	1958	2,660	1,430	550	780	1,698
1959-60	1960	11,225	3,257	1,525	1,906	6,092
		1-milacre stocking percentage [1]				
1957-58	1958	31	23	12	15	23
1959-60	1960	71	56	32	34	56

[1] At least two seedlings.

TIME OF SEED DISPERSAL

Seedfall occurred late in 1956. Almost no seed were released during September, October, or November. Many seed were dispersed on December 3 and 4 during clear, cold weather accompanied by strong northeast winds. On December 6, about 5 inches of snow lay on the cutting unit, and spruce and hemlock seeds were evenly distributed on the snow in protected spots. On windswept areas, seeds were concentrated in sheltered pockets, around obstacles, and in numerous melt pockets on the snow surface. Apparently, when slash is covered by snow, seed may be dispersed to greater distances by blowing along the snow surface.

Seedfall in 1958-59 was extremely light, making detailed observations impossible. However, the first light seedfall was observed early in December.

A detailed record of seedfall and associated weather conditions was obtained from October 1 through December 28 during the heavy seed year of 1959-60. In southeast Alaska, fall is typically wet with south to southeast winds. This weather pattern prevailed in 1959, and the first dry period after seed ripened began on October 4.

The first seeds, consisting of Sitka spruce and western redcedar, fell on October 6, the second consecutive day of no rainfall (fig. 5). Small amounts of seed continued to fall sporadically through November 10. During this period, minimum temperatures remained generally above freezing and rainfall persisted almost continuously. During the 5 days from November 11 through November 15, the heaviest seedfall of the test period took place—61 percent of the total amount of western hemlock seed, 73 percent of spruce, and 92 percent of western redcedar.

From November 16, 1959, through the end of the test period, precipitation remained generally uniform and persistent. Seed continued to fall at a reduced rate through December 28, 1959, when the study was discontinued. A count of trapped seed in July 1960 showed that the bulk of seedfall occurred after December 28, 1959. Total seed dispersed during the test period was 9.4 percent for hemlock, 22.2 percent for spruce, and 40.7 percent for western redcedar. Total seed production from October 6, 1959, through July 1960 was 26,646,000 western hemlock, 3,383,000 Sitka spruce, and 42,179,000 western redcedar seeds per acre.

During the 5 days of heaviest seedfall, prevailing wind direction was northerly with average hourly velocities up to 6 miles per hour, and gusts up to 20 miles per hour were estimated. On the last day of exceptionally heavy seedfall, wind direction switched to southerly shortly before noon. Temperatures were below freezing during the 5 days except for a maximum of 37° F. on November 11. No precipitation occurred during the period except for 0.12 inch of dry snow on November 13. Although including only part of the period during which seed-

fall occurred, the test confirmed previous observations that cones open during clear, cold weather. In southeast Alaska, northerly winds are generally associated with periods of dry weather, although local wind direction may be modified greatly by topography.

SUBSEQUENT SEEDLING GERMINATION AND EARLY SURVIVAL

The effect of seedbed and drainage conditions on germination and early survival was noted on seven seedbed types and two drainage classes (table 3). Seedlings germinating in 1957 were from sown seed and natural seedfall, whereas those germinating in 1958 were from natural seedfall alone.

Imperfectly drained mineral soil offered the best seedbed for establishment and early survival of both hemlock and spruce. During the abnormally hot and dry summer of 1958, partial shade offered by moderate slash appeared to aid seedling establishment. The additional moisture offered by imperfectly drained seedbeds was especially helpful for seedling establishment during this dry season, and few seedlings became established on well-drained seedbeds.

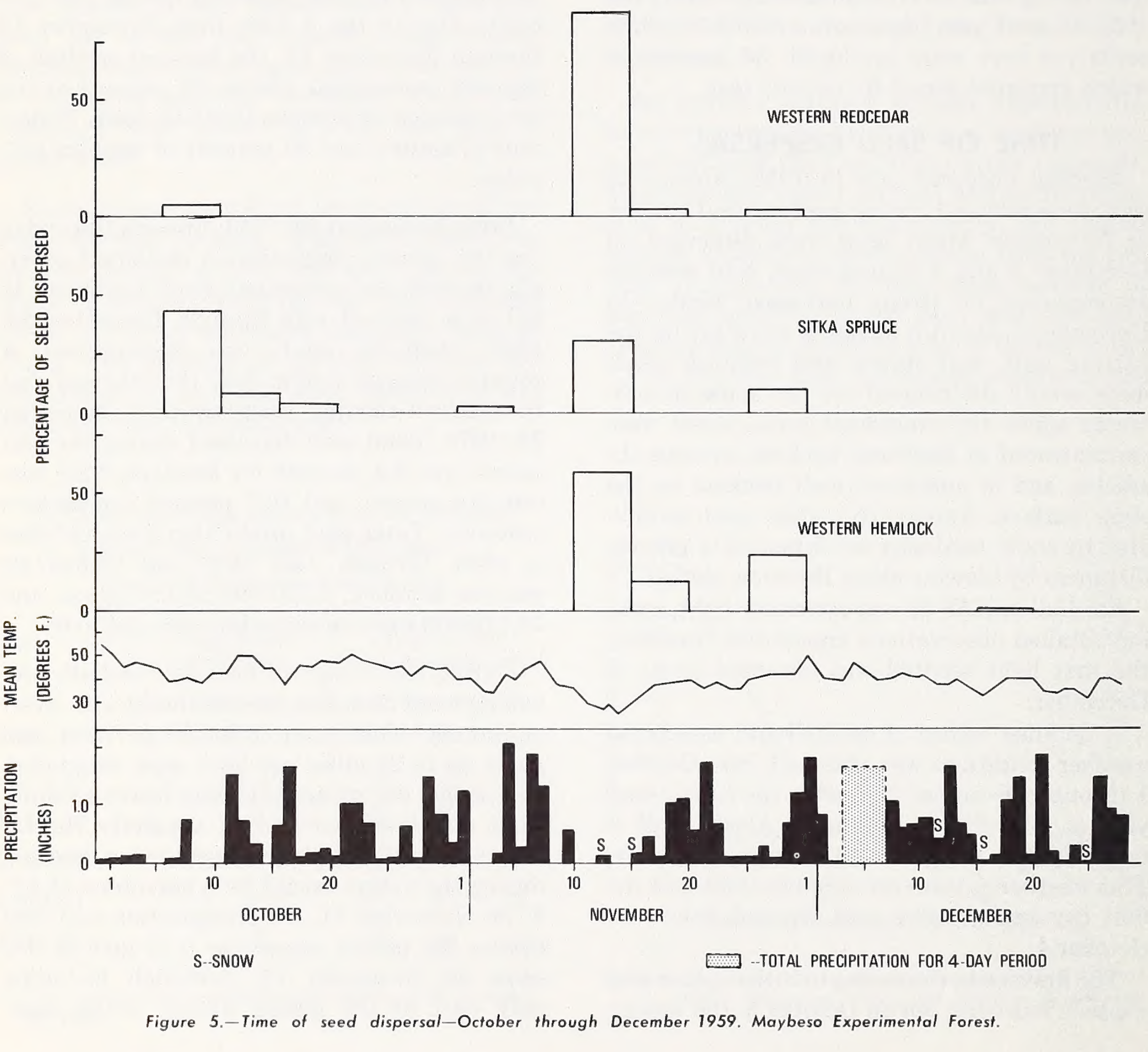

Figure 5.—Time of seed dispersal—October through December 1959. Maybeso Experimental Forest.

Table 3.—*Germination and survival of western hemlock and Sitka spruce seedlings, by drainage and seedbed conditions; mile-square cutting unit, Maybeso Experimental Forest*

YEAR OF GERMINATION AND SEEDBED CONDITIONS	GERMINATION			SURVIVAL AFTER:					
				One growing season			Two growing seasons		
	Imperfect drainage		Good drainage	Imperfect drainage		Good drainage	Imperfect drainage		Good drainage
	Number of seedlings per 1-milacre plot								
1957:									
Mineral soil	†80	*	56	19	—	2	†15	*	1
Low shrub over moss	10	—	9	2	*	4	2	—	2
Slash over mineral soil	30	—	36	4	—	4	3	—	4
Rotten wood	38	*	15	11	*	3	6	*	3
Slash over moss	13	*	3	3	*	0	3	—	0
Moss	47	*	12	26	*	1	†26	*	1
Disturbed organic	47	*	17	9	*	6	4	—	4
1958:									
Mineral soil	†42	*	4	†35	*	3	†34	*	2
Low shrub over moss	8	*	2	2	—	1	1	—	1
Slash over mineral soil	†61	*	20	†46	*	14	†42	*	11
Rotten wood	10	*	6	7	*	4	7	*	3
Slash over moss	5	*	0	4	*	0	1	*	0
Moss	12	*	0	8	*	0	8	*	0
Disturbed organic	12	*	2	7	*	2	5	*	2

*Indicates a significant difference (at the 5-percent level) between drainage conditions within the same seedbed and year of germination.

†Indicates a significant difference (at the 5-percent level) between seedbed conditions so marked and those without symbol.

In 1957, imperfectly drained moss proved to be a good seedbed, but during 1958 few or no seedlings became established on imperfectly drained moss and none on well-drained moss seedbeds. In southeast Alaska, feather mosses, such as *Hylocomium* and others, are common beneath mature timber stands. After clearcutting, these shade-loving species give way to hair mosses, such as *Polytrichum* and others, which may immediately invade well-drained mineral soil. These mosses bind the surface, thereby preventing surface erosion. On drying out, they dissipate surface heat rapidly so that temperatures lethal to tree seedlings are seldom encountered (Smith 1951). As a general observation, spruce became established more readily on mineral soil after the invasion of hair mosses.

Germination and survival did not differ significantly by species except in the case of moss-covered seedbeds during 1958, when more spruce became established from natural seedfall and more of the spruce seedlings established the previous year survived.

Early height growth did not differ significantly by drainage classes, seedbeds, or species. Average heights of 1-, 2-, and 3-year-old seedlings on all seedbeds combined were 0.1, 0.2, and 0.5 foot, respectively.

ADVANCED REGENERATION

Survival and growth of advanced regeneration were measured on eight ¼-milacre (3.3 feet by 3.3 feet) plots located on imperfectly drained Wadleigh soil and well-drained alluvial soils within the mile-square cutting unit in the spring of 1955. Logging had been completed the preceding fall. Seedling numbers ranged from 11 to 75, averaging 40 on well-drained plots, and from 35 to 121 with an average of 77 on imperfectly drained plots. Initial species composition was 78 percent hemlock and 22 percent spruce on well-drained plots, 93 percent hemlock and 7 percent spruce on imperfectly drained plots.

Seven growing seasons later (1961), 55 percent of the seedlings survived on well-drained plots and 39 percent on imperfectly drained plots. Differences in survival were not significant. Greatest mortality occurred among seedlings less than 6 inches tall during the first 2 years following logging. Mortality decreased sharply during the next 2 years, and 4 to 7 years after logging almost no mortality occurred. By 1961 the remaining seedlings were competing for growing space within dense thickets (fig. 6). Dominance was well expressed

Figure 6.—Advanced seedlings on well-drained plot 8 years after logging. Mile-square cutting unit, Maybeso Experimental Forest.

by a few, and there was no evidence of stagnation.

Height growth over the 7-year test period was significantly better on well-drained plots. Hemlock grew faster than spruce on both drainages. On well-drained plots, release was evident the fourth growing season after logging (fig. 7). Average annual height growth of the three largest seedlings on each well-drained plot was 3.5 inches for the first three growing seasons after logging, 20 inches annually thereafter. On imperfectly drained plots, height growth of the three largest seedlings averaged 2 inches for the first 2 years after logging, 8 inches thereafter. Spruce showed release but to a lesser extent.

Dominant hemlock seedlings on well-drained plots reached breast height 5 years after logging. Dominant hemlock seedlings on imperfectly drained plots had not reached breast height at the termination of the study, but their growth rate indicated that they would likely reach it 8 years after logging. In 1961, species composition was 78 percent hemlock and 22 percent spruce on well-drained plots, 91 percent hemlock and 9 percent spruce on imperfectly drained plots.

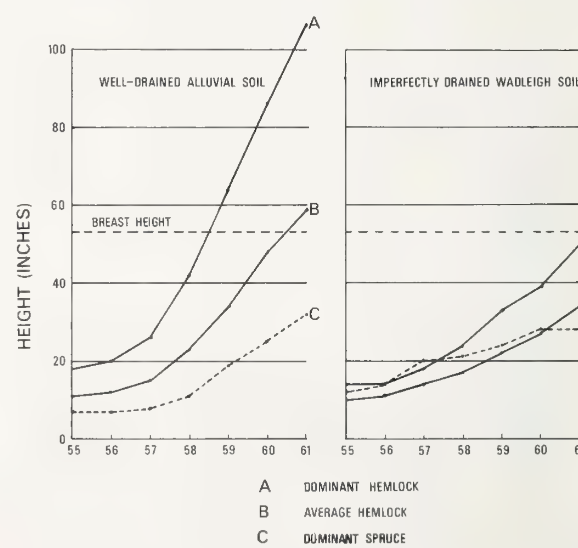

Figure 7.—Height growth of advanced hemlock and spruce seedlings by year on two sites. Mile-square cutting unit, Maybeso Experimental Forest.

TREND IN STOCKING SINCE LOGGING

The dynamic nature of natural restocking is apparent from changes in seedlings per acre and stocking percent since logging. Successive seed crops added seedlings, and mortality claimed all but the most firmly established. However, the number of seedlings 1 year and older changed little during the years following logging (fig. 8). In 1955, the area logged in 1954 contained predominantly advanced seedlings which had escaped logging. The few new seedlings present were located along roads and other areas previously disturbed. After 3 years, the effect of two seed crops was evident, with less than 1- and 2-year-old seedlings more than offsetting mortality of advanced seedlings. In 1960 many seedlings germinated from the excellent 1959-60 seed crop. Hemlock germinated profusely on a wide variety of seedbeds, many of which proved to be incapable of sustaining growth. Mortality of advanced reproduction continued. By 1962 most of the seedlings which germinated in 1960 were gone, the few remaining little more than offsetting losses of older seedlings. Advanced and subsequent seedlings were not tallied separately.

During the 8 years since logging, the percentage of plots stocked with at least one 1-year-old seedling showed a consistent increase from 38 to 69 percent (fig. 9). Thus, regeneration surveys should not be made too soon after logging. Five years appears to be a reasonable time to allow for natural regeneration, and extensive surveys should not be made sooner. If we also accept two or more 1st-year seedlings as evidence of stocking, the changes are less consistent, showing the influence of good seed years and heavy mortality of new sprouts. Because of this high initial mortality, two or more 1st-year seedlings should not be considered as evidence of stocking, and 1st-year seedlings should not be counted when seedling density is estimated.

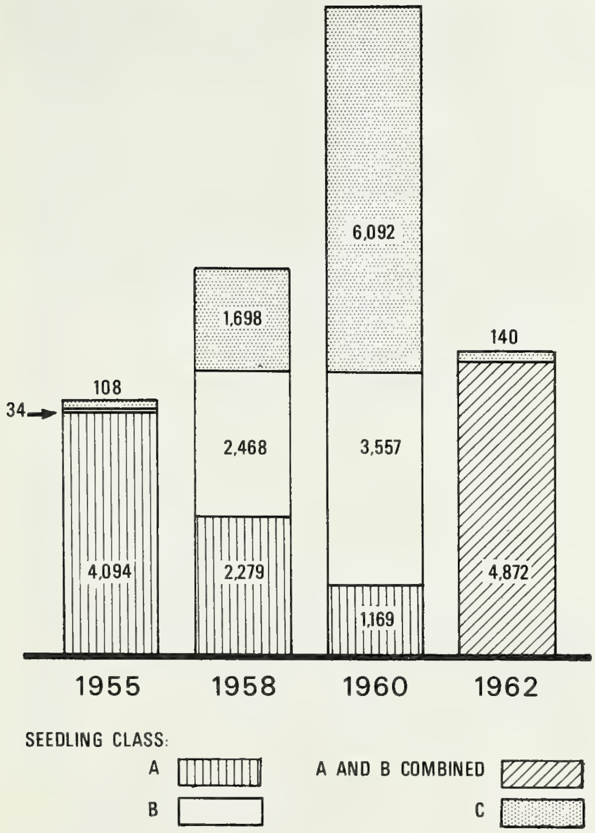

Figure 8.—Average number of seedlings per acre by year and age class: A—advanced seedlings; B—subsequent seedlings at least 1 year old; C—less than 1 year old. Mile-square cutting unit Maybeso Experimental Forest.

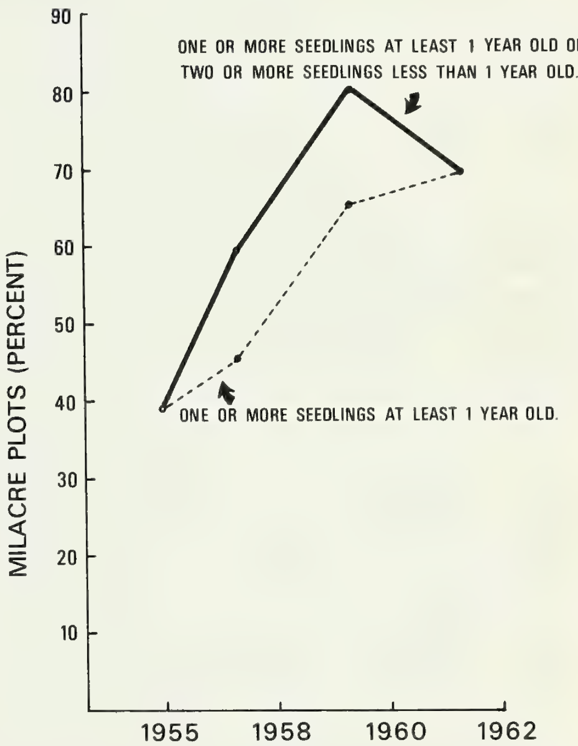

Figure 9.—Percentage of 1-milacre plots stocked by year. Mile-square cutting unit, Maybeso Experimental Forest.

REPRODUCTION 8 YEARS AFTER LOGGING

In 1962, 8 years after logging began, the mile-square cutting unit, as a whole, was well stocked. Stocking percent on the basis of both 1-milacre and 4-milacre plots decreased with increasing distance from seed source, with stocking of all zones within the level considered desirable by regional standards[6] (table 4). Stand density, as measured by number of seedlings per acre, decreased with increasing distance from seed source to 30 chains, increasing slightly beyond.

Table 4.—*Regeneration conditions on cutting unit 8 years after logging began (1962); mile-square cutting unit, Maybeso Experimental Forest*

DISTANCE FROM SEED SOURCE (CHAINS)	PLOTS STOCKED[1]		STAND DENSITY		
	1-milacre	4-milacre	Total stand	Seedlings at least 1 year old	Seedlings at least 1 year old (limit 15 per milacre plot)
	Percent		*Stems per acre*		
0-10	77	88	7,215	6,900	4,938
10-20	68	82	4,220	4,180	3,740
20-30	63	78	2,627	2,627	2,203
30+	53	75	2,940	2,940	2,938
Adjusted mean	69	83	5,012	4,872	4,305

[1] At least one seedling over 1 year old.

The difficulty of sampling natural regeneration is well known. Stocking percent, based as it is on a unit of area, gives an indication of seedling dispersal and defines the minimum number of seedlings per acre. For example, if 100 percent of 4-milacre (1/250 acre) plots were stocked, at least 250 trees per acre would be present. One-hundred-percent stocking of 1-milacre (1/1,000 acre) plots would likewise mean that at least 1,000 trees per acre were present. However, because stocked plots often contain more than one seedling, stocking percent gives no indication of the actual number of seedlings present.

On the other hand, stand density, measured by the average number of seedlings per acre, can be misleading since it tells nothing about seedling distribution. This is especially true in the case of natural regeneration, which is characteristically uneven or patchy because of differences in microsites, seedfall pattern, vegetation competition, ground disturbance, and other factors. Taken together, stocking percent and number of seedlings per acre provide a more detailed description of reforestation.

When small plots are sampled, uneven seedling distribution results in many plots with few or no seedlings and an occasional plot with many seedlings. In the past, attempts have been made to reduce the effect of plots containing dense clumps of seedlings by limiting the number of seedlings counted on each plot. For example, Cowlin (1932) limited seedling counts to 11 on 4-milacre plots. Munger (1945) limited seedlings to 15 on 4-milacre plots, and Allen et al. (1951) limited seedling counts to 12 trees on 1-milacre plots or 24 trees on 4-milacre plots.

In the study reported here, the tendency of seedlings to occur in clumps was apparent (table 5). Hemlock seedlings tended to occur in dense clumps more often than spruce or cedar. Because few 1-milacre plots contained more than 15 seedlings, this was chosen as an upper limit to be counted in some of the office calculations. Limiting seedling counts to 15 gave less weight to the few extremely dense plots, reducing the estimated average number of stems per acre on the cutting unit as a whole by 13 percent. The estimates of stand density shown in the last column of table 4 are therefore the most descriptive.

The good restocking level of the mile-square cutting unit was typical of natural regeneration on many cutting units in southeast Alaska. Regeneration surveys, made between 1957 and 1962 by eight Ranger Districts on 218 cutting units from 1 to 14 years after logging, showed that stocking averaged 80 percent on some 20,000 acres of cutover land examined. Less than 0.5 percent of this area was below the 40-percent stocking level which is adequate.[7]

[6] Region 10 stocking standards, based on the percentage of 4-milacre plots stocked, are:
Desired stocking, 70 percent or more
Satisfactory stocking, 40-69 percent
Poor or unsatisfactory stocking, 10-39 percent
Nonstocked, less than 10 percent.

[7] Unpublished records on file at the Institute of Northern Forestry, Pacific Northwest Forest and Range Experiment Station, Juneau, Alaska.

RELATIONSHIP BETWEEN STOCKING PERCENT AND SEEDLINGS PER ACRE

A loose relationship exists between stocking percent and number of seedlings per acre — as stocking percent increases, the number of seedlings per acre also increases. This relationship has been found to vary by species and region (Bever 1949, 1952; Lynch and Schumacher 1941; Wellner 1940). Although relationships differ, all studies agree that there are actually many more seedlings per acre than the minimum number indicated by stocking percent.

The relationship between stocking percent and seedlings per acre was developed by arbitrarily dividing the mile-square cutting unit into 32 parts, each containing 10 plots, and relating stocking percent to seedlings per acre on each. The resulting relationships (figs. 10 and 11), although based on limited data, show that the actual number of seedlings per acre greatly exceeds the lower limit indicated by stocking percent.

Extensive stocking surveys of the type used here fail to reveal small areas of extremely dense

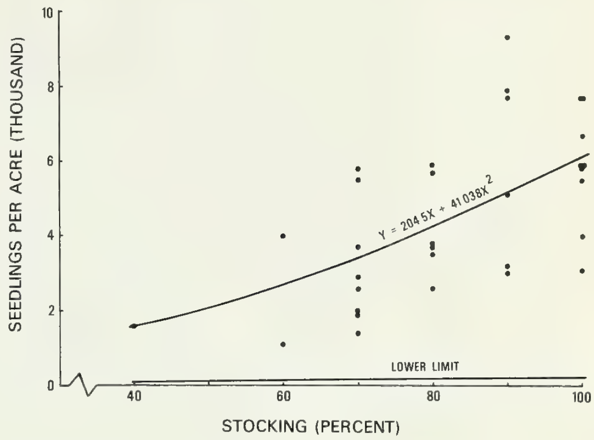

Figure 11.—Relationship of 4-milacre stocking percent (the percentage of 4-milacre plots containing at least one tree, 1 or more years old) to number of trees per acre. Mile-square cutting unit, Maybeso Experimental Forest.

Table 5.—*Percent of 1-milacre plots containing various numbers of seedlings at least 1 year old, by species, 1962; mile-square cutting unit, Maybeso Experimental Forest*

SPECIES	NUMBER OF SEEDLINGS PER PLOT								
	0	1-5	6-10	11-15	16-20	21-30	31-40	41-50	50+
	Percent								
Hemlock	51	33	9	4	0	1	1	0	1
Spruce	46	44	7	2	0	1	0	0	0
Cedar	87	12	0	1	0	0	0	0	0
All species combined	31	41	14	8	1	2	1	1	1

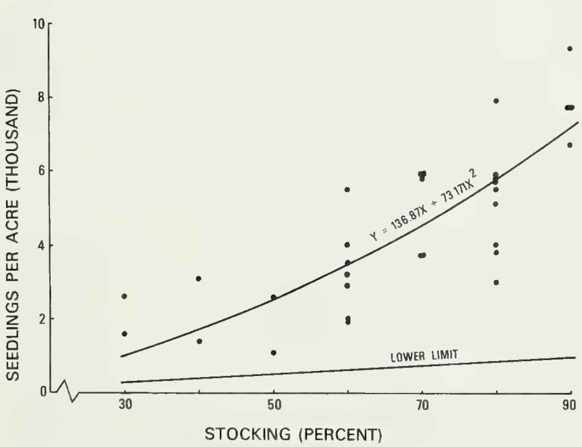

Figure 10.—Relationship of 1-milacre stocking percent (the percentage of 1-milacre plots containing at least one tree, 1 or more years old) to number of trees per acre. Mile-square cutting unit, Maybeso Experimental Forest.

stocking. Such areas were common throughout the cutting unit. Although dominance was well expressed by tree individuals and there was no evidence of stagnation, such stands would doubtless benefit from early thinning. More detailed observation will be needed to locate them for treatment.

SPECIES COMPOSITION

Hemlock has been the dominant species in the regenerating stand since logging, both in numbers and size. However, a trend toward more spruce at the expense of hemlock is evident (fig. 12). The higher percentage of hemlock soon after logging reflects the prevalence of advanced hemlock seedlings in the stand. As many of these died, more spruce became established from natural seedfall after logging. The percentage of cedar remained nearly constant.

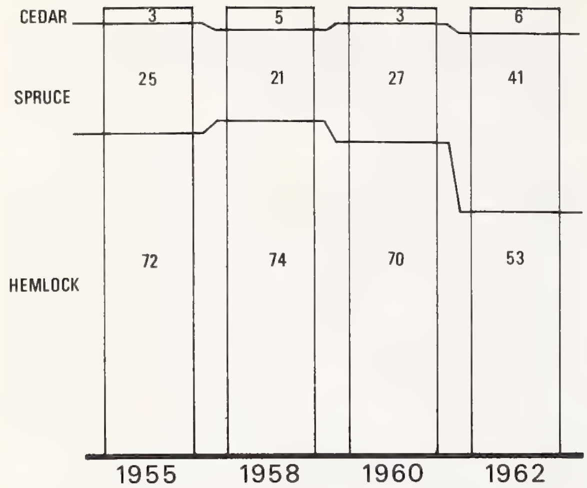

Figure 12.—Species composition in percent—seedlings at least 1 year old. Mile-square cutting unit, Maybeso Experimental Forest.

Hemlock seedlings were not only more numerous than spruce or cedar, but also tended to be larger. In 1962, a hemlock was the largest seedling present on 57 percent of 4-milacre plots examined, a spruce on 40 percent, and a cedar on 3 percent. Dominant hemlock seedlings averaged 5 feet in height with a maximum of 11 feet, dominant spruce seedlings averaged 2 feet in height with a maximum of 5 feet, and dominant cedar averaged 2 feet in height with a maximum of 3 feet. Hemlock seedlings were larger because more were advanced seedlings, well established before logging, that survived to become the dominant early stand component.

How far the present trend in species composition toward more spruce will continue is uncertain now. Taylor (1934) found that second-growth stands in southeast Alaska usually contained from 10 to 75 percent spruce by basal area, depending on soil type and stand age, and estimated that, on the average, the proportion of spruce in second-growth stands at the end of a rotation period of 75 to 100 years will be about 50 percent.

DESCRIPTION OF NONSTOCKED PLOTS

In 1962, ninety-nine 1-milacre plots, or 31 percent of the total examined were not stocked with coniferous seedlings (fig. 13).

Disturbed soil was the most common surface condition on nonstocked plots. Soil movement on all but one plot was the result of landslides

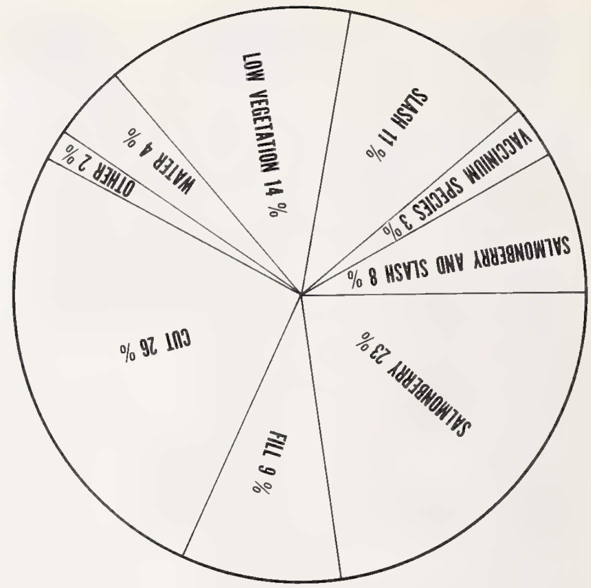

Figure 13.—One-milacre nonstocked plots by percentage of ground cover or surface condition, 1962. Mile-square cutting unit, Maybeso Experimental Forest.

or debris flows occurring after 1958. Slides are common on steep, forested slopes throughout southeast Alaska, but their frequency may increase after logging. For example, the frequency of slides on the steep hillsides of Maybeso valley increased by a factor of 50 in the 10 years since logging (Bishop and Stevens 1964).

Landslides and debris avalanche flows may seriously retard regeneration by removing the soil mantle down to glacial till or rock on steep slopes and by covering high-site land on lower slopes and the valley bottom with debris and rubble (fig. 14). Under natural conditions, the lower parts of slides quickly revegetate, pass through a red alder successional stage, and eventually support excellent stands of spruce. Alder contributes to the buildup of nutrients in mineral soil, and from this standpoint, may be beneficial to the future spruce crop. For example, net annual accumulation of 700 pounds of organic carbon and 55 pounds of nitrogen per acre per year has been measured under a 50-year-old alder stand which originated on the bare mineral soil of a glacial moraine (Crocker and Major 1955). On the other hand, the time required to pass through the alder successional stage will add many years to the rotation period of the future merchantable stand. Alder control will be necessary on

these areas to produce a merchantable conifer stand in a shorter time. Upper portions of slides, where soil was removed to glacial till, appeared to be still actively sloughing and contained no vegetation.

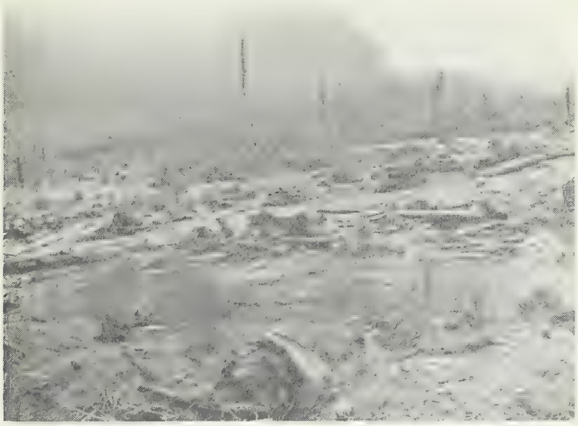

Figure 14.—Deposition of soil, rock, and logging debris on a formerly well-stocked site, 1962. Note alder in foreground. Mile-square cutting unit, Maybeso Experimental Forest.

Dense salmonberry brush, sometimes together with logging slash, was the second most common surface condition on nonstocked plots. Salmonberry brush occurred on gently sloping alluvium at scattered locations but was most common on flat, well-drained Tonowek soil along Maybeso Creek on good sites subject to periodic high water table and recurring floods (fig. 15). Dense brush patches were often located near a good spruce and hemlock seed source. Tree seedlings appeared to be confined largely to raised microsites on or beside stumps, on rotten logs, or on hummocks. Leaders of spruce seedlings were often abraded by surrounding brush.

Before the logging operation, these alluvial soils supported open stands of spruce and hemlock with a dense understory of salmonberry, elderberry, thimbleberry, and devilsclub. Many of the original trees were stilt-rooted, having germinated on down logs or upturned roots. Being along the creek, the areas were near the periphery of high-lead settings where ground

Figure 15.—In 1962, flat alluvial land near Maybeso Creek supported dense salmonberry brush and was poorly stocked with conifer seedlings.

disturbance from logging was slight. The well-established brush was damaged little by logging, and it resprouted quickly when timber was cut. There appears to be little possibility of natural restocking here within a reasonable time, and brush control, together with seeding or planting, will be necessary. Included within these areas, small, bare patches devoid of brush and seedlings suggest that brush competition alone is not the only cause of nonstocking. The fact that many seedlings are on raised microsites points to the possibility that drainage is an important factor. Seedlings could fail to become established as a direct result of a high water table, periodic flooding, frost heaving, or other reasons. Seedbed treatment in addition to brush removal and planting may be needed to reclaim these sites for timber production.

A similar restocking problem exists in coastal Oregon (Ruth 1956) where research has shown that stocking may be improved by brush control and planting immediately after logging.

Figure 16.—Spruce seedlings beneath alder on a skidroad 8 years after logging. The spruce is spindly because it lacks sufficient light. Mile-square cutting unit, Maybeso Experimental Forest.

Low vegetation, composed of bunchberry dogwood, currant, five-leaved bramble, fern, grass, moss, sedge, etc., was the third most frequent cover on nonstocked plots. However, competition from this vegetation did not appear likely to impede seedling establishment.

Neither logging slash nor *Vaccinium* brush appeared to seriously impede regeneration. Slash distribution is uneven, with only scattered, small areas occupied by slash accumulations dense enough to prevent seedling establishment. *Vaccinium* tends to occur in small clumps and is seldom uniform over large areas. Tree seedlings usually become established in the intervening spaces between clumps.

Alder did not appear to be a serious problem on the cutover, being mostly confined to disturbed ground along the edges of a few primary roads, on skidtrails, and in borrow areas. By 1962, alder was also coming in densely on gravel outwash from recent landslides and debris flows (fig. 16).

An attempt was made in 1954 to remove the alder seed source in Maybeso valley by poisoning trees growing along Maybeso Creek (Andersen 1955b). Although not completely successful, the attempt probably helped to limit alder establishment. Surviving alder trees along the creek and scattered trees in timber near the cutover perimeter provided seed, and by 1960, trees established within the cutover since logging were producing seed. With this added seed source, outwash from landslides and debris flows was subject to rapid colonization by alder. Spruce seedlings were often present beneath alder (fig. 16), and although their color was good, they were spindly and slow growing because of inadequate light. As previously stated, some alder control will be necessary.

SUMMARY AND CONCLUSIONS

Eight growing seasons after logging began, the mile-square cutting unit, as a whole, was well stocked, as shown by the regeneration survey. However, it was apparent that stocking was far from uniform, with some small areas occupied by dense thickets of spruce and hemlock and others sparsely stocked. Because problem areas were localized, the extensive stocking survey based on widely separated milacre or 4-milacre plots failed to reveal their location, and they were only identified by close observation of the area.

Extremes of stocking and stand density appeared to be related to site rather than to seed source. No lack of seed on any part of the cutting was apparent, either from the regeneration survey or from general observation. The mile-square cutting unit is situated so that the most effective seed source is located at the upper edge

and to the north of the cutting unit, apparently offering ideal conditions for seed dispersal over long distances. Some of the densest stocking was farthest from seed source, near the center of the cutting unit, on well-drained, gently sloping alluvium.

Because the mile-square cutting unit represents only one condition of topography, seed source, and soil, it is obviously impossible to extend the results of the study to all cuttings in southeast Alaska. However, the good restocking level of the mile-square cutting unit agreed with regeneration surveys made recently by eight Ranger Districts on many cutting units from 1 to 14 years after logging.

Large-scale clearcutting has been done only recently in southeast Alaska. Timber distribution, topography, and consideration of fire hazard, wildlife, or esthetic values have usually limited the size of cutting units, so that few have been made as large as the mile-square cutting unit described here. Until more experience with natural regeneration becomes available, caution should be used in planning cutting units this large. When planning large cutting units, the land manager should bear in mind that most seed is dispersed from a northerly direction and, although a seed source located high on the northerly side of a cutting unit may be effective up to 40 chains or more, seed dispersal distance may be less if the seed source is at a lower elevation or located to the south.

Extensive regeneration surveys need not be made on all land after logging. However, they should be made on alluvial soils and on areas over 40 chains from a high northerly or westerly seed source. In addition, close observation is needed to reveal small problem spots which may not be detected from extensive surveys. Because of their great 1st-year mortality, seedlings less than 1 year old should not be included in estimates of seedling density, and two or more seedlings less than 1 year old should not be considered as evidence that a plot is stocked. Five years appears to be a reasonable time to allow for natural regeneration, and surveys should not be made sooner.

Flat, streamside alluvial sites may be identified as potential brush-threat areas before logging. Brush control together with planting may be necessary to reclaim these sites for timber production.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED

SHRUBS AND HERBS

Bunchberry dogwood . . *Cornus canadensis* L.
Stink currant . . . . *Ribes bracteosum* Dougl.
Trailing black currant *Ribes laxiflorum* Pursh
Devilsclub . . . . *Oplopanax horridus* (Sm.) Miq.
Pacific red elder . . . . . . *Sambucus callicarpa* Greene
Salmonberry . . . . *Rubus spectabilis* Pursh
Western thimbleberry . *Rubus parviflorus* Nutt.
Five-leaved bramble . . *Rubus pedatus* Smith
Ovalleaf whortleberry[8] . . . . . *Vaccinium ovalifolium* Smith
Red whortleberry[9] . . . *Vaccinium parvifolium* Smith
Alaska blueberry . . . . . *Vaccinium alaskensis* Howell

TREES

Alaska-cedar . . . . *Chamaecyparis nootkatensis* (D. Don) Spach
Red alder . . . . *Alnus rubra* Bong.
Sitka spruce . . . . *Picea sitchensis* (Bong.) Carr.
Western hemlock . . . . . *Tsuga heterophylla* (Raf.) Sarg.
Western redcedar . . . . *Thuja plicata* Donn

OTHER

Ladyfern . . . . *Athyrium filixfemina* (L.) Roth
Western bracken . . . . . *Pteridium aquilinum* (L.) Kuhn
Moss . . . . *Musci* (class)
Sedge . . . . *Carex* (sp.)

[8]/ Known locally as early blueberry.
[9]/ Known locally as red huckleberry.

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